Year: 2013

Vestibular stimulation attenuates unrealistic optimism

McKay, R ; Tamagni, C ; Palla, A ; Krummenacher, P ; Hegemann, S C A ; Straumann, D ; Brugger, P

Abstract: INTRODUCTION: Unrealistic optimism refers to the pervasive tendency of healthy individuals to underestimate their likelihood of future misfortune, including illness. The phenomenon shares a qualitative resemblance with anosognosia, a neurological disorder characterized by a deficient appreciation of manifest current illness or impairment. Unrealistic optimism and anosognosia have been independently associated with a region of right inferior frontal gyrus, the pars opercularis. Moreover, anosognosia is temporarily abolished by vestibular stimulation, particularly by irrigation of the left (but not right) ear with cold water, a procedure known to activate the right inferior frontal region. We therefore hypothesized that left caloric stimulation would attenuate unrealistic optimism in healthy participants. METHODS: Thirty-one healthy right-handed adults underwent cold-water caloric vestibular stimulation of both ears in succession. During each stimulation episode, and at baseline, participants estimated their own relative risk of contracting a series of illnesses in the future. RESULTS: Compared to baseline, average risk estimates were significantly higher during left-ear stimulation, whereas they remained unchanged during right-ear stimulation. Unrealistic optimism was thus reduced selectively during cold caloric stimulation of the left ear. CONCLUSIONS: Our results point to a unitary mechanism underlying both anosognosia and unrealistic optimism, and suggest that unrealistic optimism is a form of subclinical anosognosia for prospective symptoms.

DOI: https://doi.org/10.1016/j.cortex.2013.04.005

Originally published at:
McKay, R; Tamagni, C; Palla, A; Krummenacher, P; Hegemann, S C A; Straumann, D; Brugger, P (2013). Vestibular stimulation attenuates unrealistic optimism. Cortex, 49(8):2272-2275.
DOI: https://doi.org/10.1016/j.cortex.2013.04.005

Vestibular Stimulation Attenuates Unrealistic Optimism

RUNNING HEAD: Vestibular Stimulation and Optimism

Ryan McKay[1*], Corinne Tamagni[2*], Antonella Palla[2], Peter Krummenacher[2], Stefan C. A. Hegemann[3], Dominik Straumann[2], and Peter Brugger[2,4]

[1] ARC Centre of Excellence in Cognition and its Disorders, and Department of Psychology, Royal Holloway, University of London, United Kingdom
[2] Department of Neurology, University Hospital Zurich, Switzerland
[3] Department of Otorhinolaryngology, University Hospital Zurich, Switzerland
[4] Centre for Integrative Human Physiology, Zurich, Switzerland

[*] These authors contributed equally

Corresponding author:
Dr Ryan McKay
Department of Psychology
Royal Holloway, University of London
Egham, Surrey TW20 0EX
United Kingdom
Tel: +44 (0) 1784 41 4993
Email: ryantmckay@mac.com

Abstract

Introduction: Unrealistic optimism refers to the pervasive tendency of healthy individuals to underestimate their likelihood of future misfortune, including illness. The phenomenon shares a qualitative resemblance with anosognosia, a neurological disorder characterized by a deficient appreciation of manifest current illness or impairment. Unrealistic optimism and anosognosia have been independently associated with a region of right inferior frontal gyrus, the pars opercularis. Moreover, anosognosia is temporarily abolished by vestibular stimulation, particularly by irrigation of the left (but not right) ear with cold water, a procedure known to activate the right inferior frontal region. We therefore hypothesized that left caloric stimulation would attenuate unrealistic optimism in healthy participants.

Methods: Thirty-one healthy right-handed adults underwent cold water caloric vestibular stimulation of both ears in succession. During each stimulation episode, and at baseline, participants estimated their own relative risk of contracting a series of illnesses in the future.

Results: Compared to baseline, average risk estimates were significantly higher during left-ear stimulation, whereas they remained unchanged during right-ear stimulation. Unrealistic optimism was thus reduced selectively during cold caloric stimulation of the left ear.

Conclusions: Our results point to a unitary mechanism underlying both anosognosia and unrealistic optimism, and suggest that unrealistic optimism is a form of subclinical anosognosia for prospective symptoms.

Key index words/phrases: Unrealistic optimism; Positive Illusions; Vestibular Stimulation; Caloric Irrigation; Anosognosia.

1. Introduction

Unrealistic optimism refers to the tendency of healthy individuals to underestimate the likelihood that they will experience future misfortune, including prospective illness (Weinstein, 1980, 1989). For example, people typically consider their own risks of contracting lung cancer or developing a drinking problem to be lower than the risks of their peers. Unrealistic optimism is a ubiquitous and robust phenomenon, observed across different gender, racial, national and age groups (Sharot, 2011). Along with unrealistically positive self-evaluations and exaggerated perceptions of personal control, unrealistic optimism has been identified as one of three fundamental “positive illusions” – pervasive, enduring and systematic misrepresentations of personal reality – humans are susceptible to (Taylor & Brown, 1988; Taylor, 1989).

Although most investigations of unrealistic optimism have taken place within a social-psychological framework, recently there has been growing interest in relevant neural and pharmacological mechanisms (Sharot et al., 2007, 2011, 2012a, 2012b). In a seminal study, Sharot et al. (2011) identified right inferior frontal gyrus (IFG), putatively extending into the pars opercularis, as the region of the brain responsible for coding information that should reduce positive expectations; moreover, these authors demonstrated that unrealistic optimism is associated with deficient coding of such information in this region.

Interestingly, lesions in right IFG have been associated with anosognosia, an enigmatic neurobehavioural disorder characterized by a deficient appreciation – indeed, often by explicit denial – of manifest illness or impairment. For example, Berti et al. (2005) studied the distribution of lesions in a sample of 30 patients with left hemiplegia after unilateral right-sided brain damage. These authors found that the pars opercularis of the IFG was damaged in 15 of 17 anosognosic patients. Vogel et al. (2005) demonstrated that regional cerebral blood flow (rCBF) in right IFG was significantly correlated with a measure of anosognosia for memory impairments in patients with Mild Cognitive Impairment or Alzheimer's disease.

There is an obvious qualitative resemblance between unrealistic optimism in healthy individuals and anosognosic denial after brain damage. Healthy participants display a marked asymmetry in belief updating, being relatively disinclined to revise their beliefs in response to unwelcome information (Sharot et al., 2011; Eil & Rao, 2012). Patients with anosognosia, meanwhile, are often strikingly immune to evidence that patently disconfirms their positive beliefs (Ramachandran, 1995; Ramachandran & Blakeslee, 1998). The fact that unrealistic optimism and anosognosia have been independently associated with the same brain region suggests that the similarity between them is more than superficial. This possibility generates a key empirical prediction, deriving from the surprising finding that caloric vestibular stimulation temporarily abolishes anosognosia for hemiplegia (Cappa et al., 1987; Rode et al., 1992; Ramachandran, 1995).

Caloric vestibular stimulation is a diagnostic method for assessing peripheral vestibular function. The test involves irrigating the external ear canal with cold or warm water (or air). The temperature difference between the body and the water generates a convective current in the fluid of predominately the horizontal semicircular canal of the vestibular labyrinth. This in turn stimulates the afferent vestibular nerve, which projects to the vestibular nuclei in the brainstem and further to the ocular motor nuclei. This reflex is known as the vestibulo-ocular reflex and generates appropriate compensatory eye movements (nystagmus). Signals from the vestibular nuclei also project via the thalamus to (predominately contralateral) cortical and subcortical structures (Miller & Ngo, 2007). Notably, fMRI investigations have found that the cortical network activated during vestibular stimulation includes the pars opercularis region in the IFG (Lobel et al., 1998; Fasold et al., 2002). Remarkably, a number of studies have found that patients who previously have denied their left-sided hemisyndrome will transiently acknowledge it after left-ear irrigation with cold water (Cappa et al., 1987; Rode et al., 1992; Ramachandran, 1995).

Given evidence that i) unrealistic optimism is associated with deficient coding of unwelcome information in right IFG; ii) anosognosia is associated with lesions in this region, and iii) anosognosia is temporarily abolished by vestibular stimulation, a procedure known to activate this same region, we hypothesized that left-ear caloric stimulation, obtained by cold-water irrigation of the external auditory canal, would attenuate unrealistic optimism in healthy participants. The present study was designed to test this prediction.

2. Methods

Participants were 31 healthy right-handed adults (15 men, 20-40y) who were reimbursed 20 Swiss Francs (CHF) for their time. Handedness was verified with Chapman and Chapman's (1987) 13-item handedness scale. The study was approved by the local ethics committee of the Canton of Zurich, and written informed consent was obtained from all participants. Prior to caloric irrigation (CI), each participant underwent an otological examination to ensure an intact tympanic membrane and, if necessary, to clear the external auditory canal. Participants were oriented in a supine position with the head inclined 30° from the horizontal and cold water (24°C) was irrigated into the external auditory canal on one side (Fitzgerald & Hallpike, 1942). After both vestibular-evoked eye movements and vertigo had stopped, the procedure was repeated on the other side. Eye movement recordings with video-oculography verified successful vestibular stimulation. Vestibular nystagmus was quantified by the peak slow-phase eye velocity elicited by each irrigation. Slow phase eye movement during left-ear CI (Mean = 24.9 °/s, *SD* = 13.9) was not significantly different to that during right-ear CI (Mean = 27.1 °/s, *SD* = 15.3), $t_{30} = .90$, $p = .373$.

Participants were asked to estimate their own risk, relative to that of their peers (same age, sex and education), of contracting a series of illnesses. The risk rating scale ranged from -6 (lower risk) to +6 (higher risk). Each participant was tested in three conditions, with 5 minutes rest between each: baseline with no CI (always first), left-ear CI and right-ear CI (order counterbalanced). In the latter conditions risk-estimation was initiated after 30 seconds of CI, when nystagmic response had built up. Ten illnesses were rated in each condition and the average risk estimate per condition (mean of 10 ratings) was calculated for each participant. The 30 illnesses used in this study (see Tab. 1) were selected from a larger pool of illnesses pre-rated by a separate group of 30 healthy participants. To adapt the stimuli to the within-subjects design, we created three different lists of 10 illnesses (which we counterbalanced across conditions) matched with respect to word length ($F_{2,27}$ = .17, p = .845), linguistic frequency ($F_{2,27}$ = .08, p = .923), perceived harmfulness ($F_{2,27}$ = .05, p = .951), perceived avoidability ($F_{2,27}$ = .61, p = .551), and own experience and exposure ($F_{2,27}$ = .06, p = .942).

____

(Insert Tab. 1 about here)

____

3. Results

Overall, our participants were unrealistically optimistic about their chances of contracting illnesses at baseline (Mean risk estimate = -1.59, SD = 1.24; t_{30} = 7.16,

$p < .001$), during left-ear CI (Mean = -1.14, $SD = 1.55$; $t_{30} = 4.11$, $p < .001$), and during right-ear CI (Mean = -1.37, $SD = 1.36$; $t_{30} = 5.6$, $p < .001$). As predicted, a one-way repeated measures ANOVA revealed a significant effect of *condition* (baseline, left-ear CI, right-ear CI) on the magnitude of average risk estimate, $F_{2,60} = 3.64$, $p = .032$, $\eta p^2 = .108$. Post-hoc tests using the Bonferroni correction revealed that, compared to baseline, average risk estimates were significantly higher during left-ear CI ($p = .016$), whereas they remained unchanged during right-ear CI ($p = .476$). Unrealistic optimism was thus reduced selectively during left-ear stimulation.

4. Discussion

Unrealistic optimism refers to the widespread tendency of healthy individuals to produce positively biased appraisals of their future prospects (Weinstein, 1989; Sharot, 2011). A number of authors (e.g., Ramachandran & Blakeslee, 1998; Dunning, 2005; McKay & Anderson, 2007; Bayne & Fernández, 2009) have noted the qualitative similarity between such commonplace 'misbeliefs' (McKay & Dennett, 2009) and the delusional denial evinced by anosognosic patients. Here we showed that cold caloric stimulation of the left ear, a neurological procedure known to temporarily abolish anosognosia, also attenuates unrealistic optimism in healthy participants.

Our results point to a unitary neurocognitive mechanism underlying both anosognosia and unrealistic optimism (McKay & Anderson, 2007). We speculate that anosognosia stems, at least in part (Orfei et al., 2007; Aimola Davies et al., 2009), from damage to a region of the brain that integrates undesirable information, and that vestibular stimulation abolishes anosognosia by restoring or augmenting this specific processing function. Converging evidence from lesion studies of anosognosia (Berti et al., 2005) and from fMRI investigations of unrealistic optimism (Sharot et al., 2011) and vestibular stimulation (Lobel et al., 1998; Fasold et al., 2002) implicates the pars opercularis in right IFG as the region in question. In putting forward this suggestion, we emphasise some limitations of our study. First, our paradigm did not involve presenting participants with feedback about their estimates (cf. Sharot et al., 2011), so we could not directly investigate how vestibular stimulation affects the updating of prior beliefs. Second, we did not measure brain activity directly, so our suggestion that vestibular stimulation affects information processing in right IFG is speculative. We recommend that future extensions of our work seek to clarify these issues by combining caloric vestibular stimulation with prediction error paradigms and neuroimaging. We predict that left-ear vestibular stimulation will activate right IFG, selectively augmenting belief updating following undesirable prediction errors.

We also recommend additional investigations with anosognosic patients. Although important group studies on such patients exist (e.g., Berti et al., 2005), none have assessed the efficacy of vestibular stimulation in remediating anosognosia. At present, therefore, we do not know how reliably this technique ameliorates anosognosia, nor do we know which (if any) factors modulate the effect. Moreover, to our knowledge no previous studies have investigated whether vestibular stimulation attenuates anosognosia for symptoms other than hemiplegia. We hope that future studies will address these questions.

As with other neuropsychological impairments, anosognosia is defined negatively: just as alexia denotes an inability to perceive or process lexical items and apraxia denotes impaired praxis, anosognosia denotes impaired 'nosognosia'. But what *is* nosognosia? Etymologically, the term connotes knowledge that one is ill: patients with anosognosia are unwell or impaired, but simply don't know it. However, given the striking resistance to acknowledging their impairments that anosognosic patients typically display (Ramachandran, 1995; Ramachandran & Blakeslee, 1998), a more appropriate definition of nosognosia might reference unbiased beliefs about illness; after all, patients with anosognosia are not just incidentally but *systematically* agnosic for illness. On this definition, unrealistic optimism can be viewed as a form of subclinical anosognosia for prospective symptoms. Our finding that unrealistic optimism is attenuated by a procedure known to abate anosognosia lends weight to this conception.

Acknowledgments: We are grateful to two anonymous reviewers for helpful comments on a draft of this manuscript. We also thank Max Coltheart, Mike Anderson, Jack Pettigrew, Trung Ngo, Narender Ramnani and Matthew Apps for valuable discussions, and Erika Knobloch and Susann Eisenring for technical assistance. We acknowledge the financial support of the Swiss National Science Foundation, the Betty and David Koetser Foundation for Brain Research, and the Cogito Foundation. None of these funding sources had any role in study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

References

Aimola Davies AM, Davies M, Ogden JA, Smithson M, and White RC. Cognitive and motivational factors in anosognosia. In *Delusion and Self-deception: Affective and Motivational Influences on Belief Formation* (ed. T. Bayne & J. Fernández), pp. 187-225. Hove: Psychology Press, 2009.

Bayne T and Fernández J. *Delusion and Self-deception: Affective and Motivational Influences on Belief Formation*. Hove: Psychology Press, 2009.

Berti A, Bottini G, Gandola M *et al.* Shared cortical anatomy for motor awareness and motor control. *Science*, 309: 488-491, 2005; DOI 10.1126/science.1110625

Cappa SF, Sterzi R, Vallar G, and Bisiach E. Remission of hemineglect and anosognosia during vestibular stimulation. *Neuropsychologia, 25* (5): 775-782, 1987.

Chapman LJ and Chapman JP. The measurement of handedness. *Brain and Cognition*, 6: 175-183, 1987.

Dunning D. *Self-insight: Roadblocks and Detours on the Path to Knowing Thyself (Essays in Social Psychology)*. Psychology Press, 2005.

Eil D and Rao J-M. The Good News-Bad News Effect: Asymmetric processing of objective information about yourself. *American Economic Journal: Microeconomics*, 3: 114-138, 2012.

Fasold O, von Brevern M, Kuhberg M *et al.* Human vestibular cortex as identified with caloric stimulation in functional Magnetic Resonance Imaging. *NeuroImage*, 17: 1384–1393, 2002; DOI 10.1006/nimg.2002.1241

Fitzgerald G and Hallpike CS. Studies in human vestibular function I: Observations on the directional preponderance of caloric nystagmus (nystagmus bereitschaft) resulting from cerebral lesions. *Brain*, 65: 115-137, 1942.

Lobel E, Kleine JF, Bihan DL *et al.* Functional MRI of galvanic vestibular stimulation. *Journal of Neurophysiology*, 80: 2699–2709, 1998.

McKay R and Anderson M. Reconciling psychodynamic and neurological perspectives on denial. *Cortex,* 43: 1102-1103, 2007.

McKay R and Dennett D. The evolution of misbelief. *Behavioral and Brain Sciences, 32*: 493-561, 2009.

Miller SM and Ngo TT. Studies of caloric vestibular stimulation: Implications for the cognitive neurosciences, the clinical neurosciences and neurophilosophy. Acta Neuropsychiatrica, 19: 183–203, 2007.

Orfei MD, Robinson RG, Prigatano GP *et al.* Anosognosia for hemiplegia after stroke is a multifaceted phenomenon: a systematic review of the literature. *Brain*, 130: 3075-3090, 2007; DOI 10.1093/brain/awm106

Ramachandran VS. Anosognosia in parietal lobe syndrome. *Consciousness & Cognition*, 4 (1): 22-51, 1995.

Ramachandran VS and Blakeslee S. *Phantoms in the Brain: Human Nature and the Architecture of the Mind*. London: Fourth Estate, 1998.

Rode G, Charles N, Perenin M-T, and Vighetto A. Partial remission of hemiplegia and somatoparaphrenia through vestibular stimulation in a case of unilateral neglect. *Cortex*, 28 (2): 203-208, 1992.

Sharot T. The optimism bias. *Current Biology*, 21 (23): R941-R945, 2011.

Sharot T, Guitart-Masip M, Korn CW *et al.* How dopamine enhances an optimism bias in humans. *Current Biology*, 22 (16): 1477–1481, 2012a; DOI 10.1016/j.cub.2012.05.053

Sharot T, Kanaib R, Marston D *et al.* Selectively altering belief formation in the human brain. *PNAS Early Edition*, 2012b; DOI 10.1073/pnas.1205828109

Sharot T, Korn CW, and Dolan RJ. How unrealistic optimism is maintained in the face of reality. *Nature Neuroscience*, 14: 1475-1479, 2011; DOI 10.1038/nn.2949

Sharot T, Riccardi AM, Raio CM, and Phelps EA. Neural mechanisms mediating optimism bias. *Nature*, 450 (7166): 102-105, 2007; DOI 10.1038/nature06280

Taylor SE. *Positive Illusions: Creative Self-deception and the Healthy Mind*. New York: Basic Books, 1989.

Taylor SE and Brown JD. Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, 103: 193–210, 1988.

Vogel A, Hasselbalch SG, Gade A *et al.* Cognitive and functional neuroimaging correlates for anosognosia in Mild Cognitive Impairment and Alzheimer's disease. *International Journal of Geriatric Psychiatry*, 20: 238–246, 2005; DOI 10.1002/gps.1272

Weinstein ND. Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, 39: 806-820, 1980.

Weinstein ND. Optimistic biases about personal risks. *Science*, 246 (4935): 1232-1233, 1989.

Table 1. Lists of illnesses rated by participants (English translations in parentheses).

List 1	List 2	List 3
Pest (plague)	Krebs (cancer)	AIDS (AIDS)
Lepra (leprosy)	Pocken (smallpox)	Grippe (flu)
Rheuma (rheumatism)	Anthrax (anthrax)	Thyphus (typhus)
Angina (angina)	Migräne (migraine)	Syphilis (syphilis)
Malaria (malaria)	Epilepsie (epilepsy)	Hirntumor (brain tumour)
Diabetes (diabetes)	Rinderwahn (mad cow disease)	Gelbsucht (jaundice)
Depression (depression)	Tuberkulose (tuberculosis)	Arthritis (arthritis)
Herzinfarkt (heart attack)	Nierenleiden (renal disease)	Schizophrenie (schizophrenia)
Lungenentzündung (pneumonia)	Magengeschwür (stomach ulcer)	Multiple Sklerose (multiple sclerosis)
Blinddarmentzündung (appendicitis)	Hirnhautentzündung (meningitis)	Mittelohrentzündung (acute ear infection)